

WHAT IS CLAIMED IS:

1. A method of producing a reflective mask comprising a substrate, a reflective multilayer film formed on the substrate to reflect exposure light, and at least one layer formed as a patterned layer on the reflective multilayer film to define a nonreflecting region for the exposure light, the method comprising the steps of:

(a) patterning a layer formed on and adjacent to a topmost layer of the reflective multilayer film; and

(b) removing a reaction product produced following patterning in the step (a) and deposited on an exposed surface of the reflective multilayer film which is exposed as a result of patterning in the step (a).

2. A method of producing a reflective mask according to claim 1, wherein:

the patterned layer defining the nonreflecting region for the exposure light comprises a laminated film including an absorber layer for absorbing the exposure light and a buffer layer made of a material resistant against an environment upon patterning of the absorber layer;

the laminated film being formed on and adjacent to the topmost layer of the reflective multilayer film, the layer patterned in the step (a) being the buffer layer.

3. A method of producing a reflective mask according to claim 1, wherein the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with a solution containing hydrofluoric acid and/or fluorosilicic acid.

4. A method of producing a reflective mask according to claim 1, wherein:

the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with an alkali aqueous solution.

5. A method of producing a reflective mask according to claim 1, wherein the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with fluorine-containing plasma.

6. A method of producing a reflective mask comprising a substrate, a reflective multilayer film formed on the substrate to reflect exposure light, and at least one layer formed as a patterned layer on the reflective multilayer film to define a nonreflecting region for the exposure light, the method comprising the steps of:

(a) patterning a layer formed on and adjacent to a topmost layer of the reflective multilayer film by the use of an oxygen-containing plasma process; and

(b) removing oxide produced following patterning in the step (a), containing a component of the topmost layer of the reflective multilayer film, and deposited on an exposed surface of the reflective multilayer film which is exposed as a result of patterning in the step (a).

7. A method of producing a reflective mask according to claim 6, wherein:

the patterned layer defining the nonreflecting region for the exposure light comprises a laminated film including an absorber layer for absorbing the exposure light and a buffer layer made of a material resistant against an environment upon patterning of the absorber layer;

the laminated film being formed on and adjacent to the topmost layer of the reflective multilayer film, the layer patterned in the step (a) being the buffer layer.

8. A method of producing a reflective mask according to claim 6, wherein the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with a solution containing hydrofluoric acid and/or fluorosilicic acid.

9. A method of producing a reflective mask according to claim 6, wherein:

the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with an alkali aqueous solution.

10. A method of producing a reflective mask according to claim 6, wherein the step (b) is carried out by bringing the exposed surface of the reflective multilayer film with the reaction product formed thereon following patterning in the step (a) into contact with fluorine-containing plasma.

11. A method of producing a reflective mask comprising a substrate, a reflective multilayer film formed on the substrate to reflect exposure light, a protection film formed on the reflective multilayer film to protect the reflective multilayer film, and at least one layer formed as a patterned layer on the protection film to define a nonreflecting region for the exposure light, the method comprising the steps of:

(a) patterning a layer formed on and adjacent to the protection film; and
(b) removing a reaction product produced following patterning in the step (a) and deposited on an exposed surface of the protection film.

12. A method of producing a reflective mask according to claim 11, wherein the step (b) is carried out by bringing the exposed surface of the protection film with the oxide formed thereon following patterning in the step (a) into contact with a solution containing hydrofluoric acid and/or fluorosilicic acid.

13. A method of producing a reflective mask according to claim 11, wherein:

the step (b) is carried out by bringing the exposed surface of the protection film with the oxide formed thereon following patterning in the step (a) into contact with an alkali aqueous solution.

14. A method of producing a reflective mask according to claim 11, wherein the step (b) is carried out by bringing the exposed surface of the protection film with the oxide formed thereon following patterning in the step (a) into contact with fluorine-containing plasma.

15. A method of producing a reflective mask according to any one of claims 1 through 14, wherein the layer formed on and adjacent to the topmost layer of the reflective multilayer film is made of a material containing Cr or Ru as a main component.

16. A method of producing a reflective mask according to any one of claims 1 through 14, wherein the reflective multilayer film comprises Mo layers and Si layers alternately laminated, the topmost layer of the reflective multilayer film being a layer made of elemental Si or a material containing Si as a main component.

17. A method of producing a reflective mask according to any one of claims 1 through 14, wherein the patterned layer defining the nonreflecting region has a layer made of a material containing Ta as a main component.

18. A method of producing a reflective mask comprising a substrate, a reflective multilayer film formed on the substrate to reflect exposure light, and at least one layer formed as a patterned layer on the reflective multilayer film to define a nonreflecting region for the exposure light, the method comprising the steps of:

(a) causing deposition of oxide on the reflective multilayer film, the oxide containing a component of the topmost layer of the reflective multilayer

film; and

(b) removing the oxide from the reflective multilayer film.

19. A method of producing a semiconductor device, comprising the step of forming a fine pattern on a semiconductor substrate by lithography using the reflective mask produced by the method according to any one of claims 1 through 14.